§37. Design of Wall Cooling System for LHD Plasma Vacuum Vessel

Inoue, N., Komori, A.

The wall cooling system of LHD Plasma Vacuum Vessel has been investigated with R&D test. First wall and water cooling system is prepared on plasma side of vessel, 80 K shield is located another side of vessel (see Fig.1). The vessel temperature is required to control lower than 70 ℃, to keep the shield temperature low. The wall cooling system is located at the narrow space (< 25 mm) between plasma and vacuum vessel on the small major radius side of the torus (radial build). Here, the cooling system with water cooling pipe and protect plate (first wall) is considered.

The maximum total heat flax of LHD is 3 MW in steady state operation (CW). In this case, a half of heat flux reaches the vessel wall and another half of heat flux reaches the divertor plate. This total heat flux of the vessel is 1.5 MW (1.5 W/cm^2 on the vessel wall at the radial build).

In the case of pulse operation (20 MW, 10 sec, 5 min interval operation), the maximum total heat flax is equivalent to 666 kW, steady state operation. Thus, the heat flux for the vessel is 333 kW (0.3 W/cm^2 on the vessel wall). In this investigation, the R&D test was performed to the case of 666 kW steady state operation.

Figure 2 shows the sample structure and heat flux. The Vacuum vessel sample (100 mm x 100 mm x T15 mm), first wall sample (100 mm x 100 mm x T10 mm), and cooling pipe sample (diameter of 10.5 mm, thickness of 1 mm) are made of stainless steel. These are fix by using capper saddle and stainless bolts. Another type of sample without first wall is prepared with the vacuum vessel sample and the cooling pipe directly fixed by cleat (thickness of 1mm) and bolts.

The test was performed by using active cooling teststand (ACT), which is developed for divertor heating test. The heat flux is supplying by electron beam (30 kV, 1mA). The temperature of vessel and first wall are measured by thermo couple (CA). The speed of cooling water is 2 m/sec in the cooling pipe.

Figure 3 shows the temperature change on vessel and first wall. In the case of sample without first wall, the temperature of vessel reached to 100 ℃ after 35 min. The first wall is very effective, because it kept the change of vessel temperature less than 10 degree after 2 hours, even if the first wall heated to 170 Âé. By using this type of first wall, the wall cooling system of vacuum vessel is possible for the pulse operation of 20MW, 10 sec, or steady state operation of 666 kW.

For the next step of cooling system design, steady state of 3 MW will investigated as higher performed cooling system. It will be considered by using such as jacket type protect panel and pipe distance change.

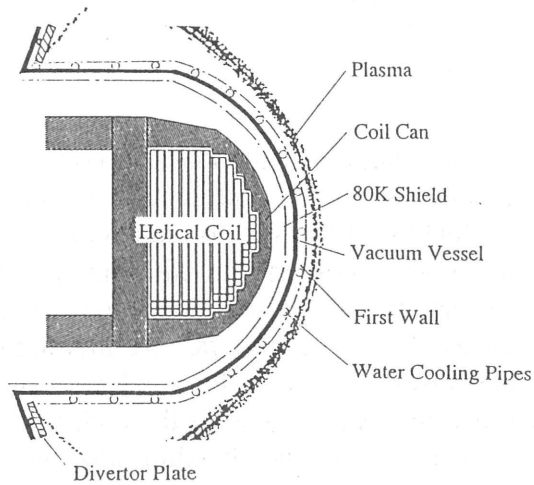

Fig. 1 Schematic of cooling systm; Water cooled vacuum vessel and first wall, Water cooled divertor plates, and 80K shield.

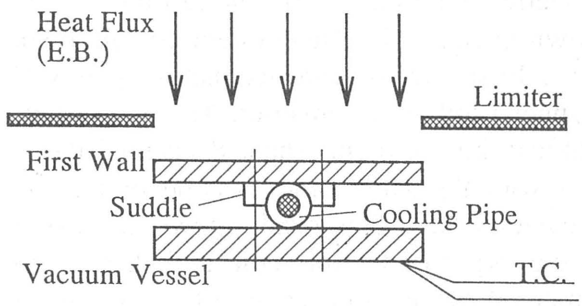

Fig.2 Schematic of heating test; the sample of vacuum vessel with water cooling pipe, saddle and first wall which is fixed by stainless bolts.

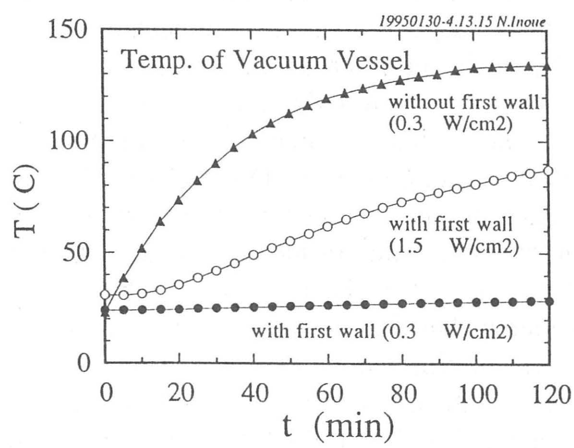

Fig. 3 Change of temperature on the plasma vacuum vessel with heating time.